

WHAT IS CLAIMED IS:

1. A method of forming a copper wiring in a semiconductor device,  
comprising:

5 a first step of providing a substrate in which a damascene pattern is  
formed in an interlayer insulating film;

a second step of forming a copper anti-diffusion conductive film and a  
copper layer on the structure including the damascene pattern;

10 a third step of forming a copper wiring by means of a chemical  
mechanical polishing process, wherein the surface of the copper wiring is  
lower than the surface of the interlayer insulating film; and

a fourth step of forming a copper anti-diffusion insulating film on the  
entire structure including the top of the copper wiring.

15 2. The method as claimed in claim 1, wherein the third step comprises  
the steps of:

overly performing a chemical mechanical polishing process so that the  
top surface of the copper wiring is concaved and formed lower than the  
surface of the interlayer insulating film; and

20 performing an annealing process so that the top surface of the copper  
wiring is changed from the concave shape to a convex shape while stabilizing  
the copper wiring.

3. The method as claimed in claim 2, further comprising the step of performing a cleaning process after the step of performing the chemical mechanical polishing process.

5           4. The method as claimed in claim 3, wherein the cleaning process is performed using a cleaning agent containing nitric acid so that the surface of the copper wiring is further lower than the surface of the interlayer insulating film.

10           5. The method as claimed in claim 2, wherein the annealing process is performed using an inert gas such as N<sub>2</sub>, Ar, H<sub>2</sub> or He or a mixed gas of them at a temperature in the range of 100°C to 500°C.

15           6. The method as claimed in claim 2, wherein the annealing process is performed using an inert gas of N<sub>2</sub>, Ar, H<sub>2</sub> or He or a mixed gas of them, or in a vacuum state at a temperature in the range of 200°C to 700°C for 1 to 5 minutes in a rapid thermal annealing process.

20           7. The method as claimed in claim 2, wherein a plasma processing is further performed between the third step and the fourth step.

8. The method as claimed in claim 7, wherein the plasma processing is carried out using a mixed gas containing nitrogen and hydrogen, a gas of a

series of ammonia, or a mixed gas of hydrogen/an inert gas not containing nitrogen as an atmosphere gas at a temperature in the range of 100°C to 350°C.

9. The method as claimed in claim 1, wherein the copper anti-diffusion  
5 insulating film is formed by covering a material having a copper anti-diffusion property and a good fluidity property by means of a spin-on-deposition method, and then performing an annealing process for the material.

10. The method as claimed in claim 9, wherein the copper anti-  
10 diffusion insulating film is formed using materials such as methyl, benzochlorobutane, polyimide, arylether and hydrogen silsesquioxane, which contain Si, C and N in a type of a sol or gel.

11. The method as claimed in claim 9, wherein the annealing process  
15 is performed using an inert gas such as N<sub>2</sub>, Ar, H<sub>2</sub> or He or a mixed gas of them at a temperature in the range of 100°C to 500°C.

12. The method as claimed in claim 9, wherein the annealing process  
is performed in a vacuum state at a temperature in the range of 100°C to 500°C.  
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13. A method of forming a copper wiring in a semiconductor device,  
comprising:

a first step of providing a substrate in which a damascene pattern is  
formed in an interlayer insulating film;

a second step of forming a copper anti-diffusion conductive film and a copper layer on the structure including the damascene pattern;

a third step of forming a copper wiring by means of a chemical mechanical polishing process, wherein the surface of the copper wiring is lower than the surface of the interlayer insulating film; and

a fourth step of forming a selective copper anti-diffusion conductive film on the top surface of the copper wiring.

14. The method as claimed in claim 13, wherein the third step comprises the steps of:

overly performing a chemical mechanical polishing process so that the top surface of the copper wiring is concaved and formed lower than the surface of the interlayer insulating film; and

performing an annealing process so that the top surface of the copper wiring is changed from the concave shape to a convex shape while stabilizing the copper wiring.

15. The method as claimed in claim 14, further comprising the step of performing a cleaning process after the step of performing the chemical mechanical polishing process.

16. The method as claimed in claim 15, wherein the cleaning process is performed using a cleaning agent containing nitric acid so that the surface of

the copper wiring is further lower than the surface of the interlayer insulating film.

17. The method as claimed in claim 14, wherein the annealing process  
5 is performed using an inert gas such as N<sub>2</sub>, Ar, H<sub>2</sub> or He or a mixed gas of them at a temperature in the range of 100°C to 500°C.

18. The method as claimed in claim 14, wherein the annealing process  
is performed using an inert gas of N<sub>2</sub>, Ar, H<sub>2</sub> or He or a mixed gas of them, or  
10 in a vacuum state at a temperature in the range of 200°C to 700°C for 1 to 5 minutes in a rapid thermal annealing process.

19. The method as claimed in claim 13, wherein a plasma processing is  
further performed between the third step and the fourth step.

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20. The method as claimed in claim 19, wherein the plasma processing  
is carried out using a mixed gas containing nitrogen and hydrogen, a gas of a  
series of ammonia, or a mixed gas of hydrogen/an inert gas not containing  
nitrogen as an atmosphere gas at a temperature in the range of 100°C to 350°C.

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21. The method as claimed in claim 13, wherein the selective copper  
anti-diffusion conductive film is formed within the damascene pattern without  
causing a step with the interlayer insulating film.

22. The method as claimed in claim 21, the selective copper anti-diffusion conductive film is formed using a metal having a high melting point such as W, Ti, Ta, etc. or a compound such as Ni, Co, P, B, etc. by means of a selective electroless plating method.

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23. The method as claimed in claim 21, the selective copper anti-diffusion conductive film is formed by means of a selective chemical vapor deposition (CVD) method.

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24. The method as claimed in claim 13, the selective copper anti-diffusion conductive film is formed using a metal having a high melting point such as W, Ti, Ta, etc. or a compound such as Ni, Co, P, B, etc. by means of a selective electroless plating method.

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25. The method as claimed in claim 13, the selective copper anti-diffusion conductive film is formed by means of a selective chemical vapor deposition (CVD) method.